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Has Education Had a Growth Payoff in the MENA Region?

by
Lant Pritchett

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Table of Contents

Summary

I. Factor Accumulation and Total Factor Productivity in MENA 1
A) Total Factor Productivity in MENA 2
B) Recent Slowdown in Growth 2
C) How to Understand Declines in TFP 5

II. Education and Growth in MENA 6

III. Quality of Schooling 9

IV. Micro Estimates of Returns to Schooling 10

V. Government Employment and Private and Social Returns to Education 11

VI. Three Additional Points 12
A) Returns to Education in Farming 12
B) Trade Reform and Returns to Education 12
C) Technological Skill Bias in the World Production Frontier 13

Conclusion 13

Appendix 1: Calculation of Observed Factor Accumulation, TFP, and Implied 14

References 17

Tables

Table 1: Regional Mean (or Median) Growth Rates Per Annum of Output Per Worker, Factor Accumulation Contribution to Growth and TFP 3
Table 2: Evolution of Output Growth and TFP Growth in Various Regions 4
Table 3: Results of Calculations of Actual and "Implied" Factor Accumulation 5
Table 4: Basic OLS Growth Accounting Regression 6
Table 5: Regional Comparisons of Education and Growth 7
Table 6: Regressions of Output Per Worker Allowing for Different 8
Table 7: Differentials in Infant Mortality and Desired Fertility, Ratio of Secondary Educated to Uneducated Women 9

Appendix Table A1.1: Description of Data Sources for TFP Calculations 15
Appendix Table A1.2: Regressions of TFP on Various Factors 16

Summary

The countries in the Middle East and North Africa (MENA) have seen an enormous expansion in the educational status of their labor force in the last thirty years. Unquestionably improved educational levels have had many benefits. Education has benefited individuals in a variety of non-economic ways in terms of better lives and healthier children. It has provided benefits in terms of higher wages for individuals who obtained jobs in the formal sector. But, examining the macroeconomic data, one sees little evidence that the rapid expansion of educational attainment has provided benefits in increased output. In the MENA countries more rapid expansion of education has not necessarily led to more rapid growth. This micro-macro puzzle raises two important points about education that are relevant for future policies in the region.

First, the growth pay-off to education depends critically on the economic environment in which the more educated labor is employed. There were a number of ways in which the strategy did not lead to economic pay-offs from education for the society at large. Under the previous economic strategy of state-led development, many educated workers demanded and received higher wages in the government sector. These wages did not reflect either higher productivity of the worker or the contribution of increased government employment to growth. The strategy of continually expanding public sector employment to accommodate the increased supply of educated workers was neither sustainable nor desirable. The region-wide shift in economic strategy towards greater openness to trade, investment and economic ideas and to more reliance on the market means that education will become more important to economic growth.

Second, the economic pay-off to growth depends on the adaptation of education to the changing demands of the economy. Quality of education, not quantity, is the key to creating true human capital. The quality of education must be continually improved if MENA countries are to enjoy dynamic gains in productivity. Moreover, the educational system serves many important social and cultural functions, but this should not prevent the educational system from responding to the changed economic strategy, and the changes in skills that it will bring.

Has Education Had a Growth Payoff in the MENA Region?
A Background Note

Has the enormous expansion in education in the Middle East and North Africa (MENA) paid off? Education unquestionably has payoffs at the individual level, in both non-market and market benefits. There are non-market benefits of education both in quantifiable and qualitative dimensions. Particularly well-documented are the improved health of individuals and of their children from increased education, particularly of mothers, and the ability of more educated women to better achieve their desired fertility. The qualitative dimensions (such as greater sense of personal well-being from literacy and numeracy) at the individual level are less easy to document, but no less important.

In addition to non-market benefits there is an enormous literature devoted to estimating the magnitude of increases in workers' productivity and wages from additional schooling. When averaged across studies and across levels of schooling in many countries, one additional year of schooling tends to increase an individual's wages by about 12 percent.

However, this strong evidence of an economic gain at the individual level raises something of a micro-macro paradox in the developing country experience, and one which is particularly relevant to the recent experience in MENA. The average years of schooling of the labor force has increased tremendously in most MENA countries and yet growth of output per capita, and particularly real wages, has often been quite slow, and in many cases strongly negative. Moreover, just as the increases in the education level of labor have been the greatest in recent years (*i.e.*, increases in enrollment rates translate into more educated laborers), the growth rates have *decelerated* massively.

This background note will explore this phenomenon of a gap between the individual and economy-wide payoffs to education in the MENA countries and propose and discuss possible analytical resolutions to the apparent paradox.

I. Factor Accumulation and Total Factor Productivity in MENA

The MENA region's growth performance in the 1960's and 1970's was relatively strong, but has been disappointing in several respects. First, the growth appears to have been entirely *extensive* due primarily to the tremendous expansion in factor accumulation, or put another way, productivity growth has been very small (and frequently negative). Second, though growth rates have decelerated rapidly, the previous investments in schooling have been paying off. Third, the payoff from the expansion in human capital appears small, since the economies were not able to absorb the tremendous expansion in educated labor (as discussed below).

A) Total Factor Productivity in MENA

In order to understand the sources of growth in output per person it is useful to decompose the observed growth rates into a component that can be attributed to factor accumulation (of physical and human capital) and a component that cannot be explained by factor accumulation (which is called, for lack of a better name, total factor productivity - TFP). Three more or less independent estimates of this growth rate decomposition are reported in Table 1.[1] All three show the same pattern for MENA: reasonably rapid growth but with nearly all of that growth explained by rapid factor accumulation with little growth of productivity.

B) Recent Slowdown in Growth

An equally worrisome aspect of the growth experience of the MENA countries, emphasized in the World Bank's publication, *Claiming the Future*, is that growth rates have fallen sharply in the region. Whereas growth rates in the MENA region up until the mid-1980s were among the fastest in the world, since then they have been among the slowest. There are three aspects relevant to a discussion on education.

First, this slowdown in growth has occurred despite vast increases in education enrollments and expansions in the stock of human capital. While primary and secondary enrollment rates have shown steady increases, the growth rate has fallen precipitously in nearly every country in MENA. Just when one would have hoped the massive investments in human capital of the 1970s and 1980s would be paying off in increases in the educational stock of the labor force, the economies have moved into a period of sluggish growth.

Second, since this deceleration in economic growth has affected output more than investment, the slowdown appears in a growth accounting sense to be the result of falls in measured TFP. Table 2 shows TFP growth for several regions including MENA over various periods. What is particularly worrisome is that while TFP appears to have *increased* in the East Asia region, it has become negative in recent years in nearly every other region—an effect that is particularly strong in the MENA countries.

[1] See Appendix 1 for the methodology used in the author's calculation.

Table 1: Regional Mean (or Median) Growth Rates Per Annum of Output Per Worker, Factor Accumulation Contribution to Growth and TFP

	Bosworth-Collins and Chen (1960-92)			Author's calculations, with various data sources					
				Summers-Heston (1960-85)			World Bank (1960-87)		
Region	GDP per capita	Factor Accumulation	TFP	GDP per capita	Factor Accumulation	TFP	GDP per capita	Factor Accumulation	TFP
MENA	1.8	2.2	-.4	2.9	3.8	.2	3.0	3.1	.1
East Asia or HPAE	4.1	3.3	.8	4.7	3.5	.9	4.7	3.7	.1
LAC	1.4	1.3	.1	1.5	1.7	-.2	1.2	1.8	-.3
OECD	2.4	1.3	1.0	2.6	1.8	.7	2.7	1.5	.8

Note: All three estimation methods use the same definitions for regional composition. However, they do not have the same number of observations across the three data sources. The author's calculations (the last six columns) report regional medians and, hence, are not additive across the columns.

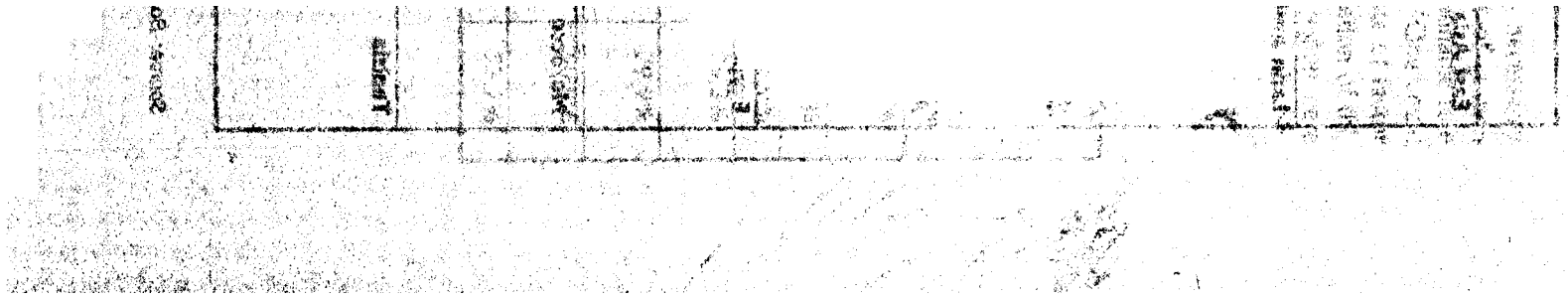

Table 2: Evolution of Output Growth and TFP Growth in Various Regions and Countries in the MENA Region

	Period	Output per worker growth	TFP growth
East Asia	1960-70	3.8	0.8
	1970-80	4.8	0.9
	1980-86	2.7	-0.4
	1986-92	5.1	1.8
Latin America	1960-70	3.2	1.6
	1970-80	2.6	0.7
	1980-86	-1.4	-2.2
	1986-92	-0.6	-1.0
Middle East and	1960-70	4.9	2.2
North Africa	1970-80	0.9	-2.4
	1980-86	-0.1	-1.6
	1986-92	0.1	-0.2
Algeria	1960-70	2.7	2.0
	1970-80	2.4	-0.2
	1980-86	0.6	-1.0
	1986-92	-2.8	-2.6
Egypt	1960-70	3.3	1.8
	1970-80	5.8	2.5
	1980-86	3.6	0.1
	1986-92	-0.2	-1.3
Morocco	1960-70	5.9	4.6
	1970-80	2.0	-0.2
	1980-86	0.7	-0.3
	1986-92	-0.6	-1.2
Tunisia	1960-70	3.9	1.7
	1970-80	3.5	1.8
	1980-86	0.1	-1.6
	1986-92	1.8	1.4

Source: Bosworth, Collins and Chen, 1995

C) How to Understand Declines in TFP

These calculations of TFP are an accounting exercise and should not be interpreted as necessarily reflecting some deep notion of "technical" progress. TFP simply tells us how much of growth cannot be accounted for by investments if one assumes these investments earned a reasonable rate of return. One possibility is that in fact investments do not make a reasonable return. One could reverse the residual calculation of TFP and ask, if TFP were at worst zero, what is the rate of factor accumulation that is implied by the observed growth? Table 3 shows one possible calculation of this type. The results imply that less than half of the investments undertaken in the MENA region were effective in creating sustained economic growth.

Table 3: Results of Calculations of Actual and "Implied" Factor Accumulation

Region[1] (number of countries)	observed factor accumulation	"observed:" TFP	if TFP = 0		if TFP = 1% p.a.	
			Implied factor accumulation	Implied/ Observed	Implied factor accumulation	Implied/ Observed
Middle East, North Africa (9)	3.53	-1.3	1.62	45.8%	0.95	26.9%
Sub-Saharan Africa (21)	2.03	-0.6	0.99	48.8%	0.17	8.4%
South Asia (6)	2.13	-0.9	1.15	54.0%	0.19	8.9%
Latin America and Caribbean (23)	1.69	-0.1	1.22	72.2%	0.41	24.3%
High Performing Asian Economies (7)	3.84	1.2	3.63	94.5%	3.07	79.9%
Other Asian Economies (4)	1.64	0.3	1.56	95.1%	0.82	50.0%
OECD (24)	1.79	1	1.75	97.8%	1.32	73.7%

Source: Pritchett, 1996.

[1] *Size of sample is given in parenthesis.*

II. Education and Growth in MENA

The above examination of factor accumulation and growth was a prerequisite to a discussion of human capital accumulation. While it is often asserted that the expansion of human capital has been an important determinant of growth rates in developing countries, this assertion is erroneous.[1] Table 4 shows the results of regressing the growth of output per worker on the rate of growth of physical and human capital per worker. The coefficient of physical capital is strongly statistically significant and of the magnitude predicted by conventional theory.[2] The educational capital coefficient on the other hand, is strongly insignificant, with the wrong sign, and clearly different from the prediction of a standard extended Solow model.

Table 4: Basic OLS Growth Accounting Regression, (Dependent Variable Growth of GDP Per Worker Per Annum)

	Barro-Lee education data[1]		Nehru-Swanson-Dubey education data[2]	
	Basic	*with initial GDPPW*	*Basic*	*with initial GDPPW*
Physical capital per worker	.524	.526	.501	.501
	(12.8)	(12.8)	(9.54)	(9.49)
Educational capital per worker	-.049	-.038	-.104	-.117
	(1.07)	(.795)	(2.07)	(2.04)
LN (Initial GDPPW)		.0009		-.0008
		(.625)		(.491)
Number of countries	91	91	79	79
R-Square	0.653	0.655	0.557	0.561

Source: Pritchett, 1996.

Notes: Absolute values of t-statistics in parenthesis constants are included but not reported.

[1] Uses King-Levine data on physical capital stocks.

[2] Uses Nehru-Dhareshewar data on physical capital stocks.

These results suggest that the expansion of schooling has not on average paid off in the expansion of output per worker in a cross section of countries. This indicates that MENA's slow and declining growth is unlikely to be attributable to slower growth of years of schooling of the

[1] Growth regressions based on enrollment rates are entirely beside the point and growth regressions with initial levels of schooling are at odds with the micro literature on wage determinants.

[2] Actually a little higher, as one would expect a physical capital share of about 0.4.

labor force. In fact, the MENA region has the *fastest* expansion of schooling of any region, including East Asia. (Table 5)

Table 5: Regional comparisons of education and growth

Region	Educational growth				Growth of output per worker
	Barro-Lee, 1960-1985		Nehru-Swanson-Dubey, 1960-1987		
	Educational capital growth	Absolute increase in years of schooling	Educational capital growth	Absolute increase in years of schooling	
Sub-Saharan Africa	4.16	1.11	4.56	1.97	0.753
South Asia	3.73	1.44	2.54	1.66	1.05
Latin America	2.46	1.77	2.74	2.44	1.58
East Asia and Pacific	2.81	2.57	4.00	2.83	3.66
Middle East and North Africa	3.98	2.38	4.74	3.19	3.99
OECD	1.78	2.22	.603	.973	2.45

The above results, though true on average for developing countries, may not hold for specific regions and thus, education may indeed have an economic growth pay-off in the MENA region. Table 6 re-estimates the growth equations, allowing the impact of education to vary across regions. The MENA region has an estimated coefficient on educational growth that is consistently lower than most other regions, and in fact is always negative for the non-oil MENA countries. The negative coefficient actually suggests that those countries in MENA that had more rapid educational expansion had *slower* growth because of it. This is implausible and thus deserves further explanation.

Table 6: Regressions of Output Per Worker Allowing for Different Education Coefficients Across Regions

	Nehru data for capital and education			Barro-Lee for education and King-Levine for Capital		
GDP Growth rate data:	*PWT5*		*World Bank*	*PWT5*		*World Bank*
Growth of capital stock per worker	.498 (9.37)	.438 (6.39)	.522 (7.17)	.524 (12.87)	.478 (9.60)	.372 (5.01)
Growth of educational capital per worker	-.116 (1.99)			-.049 (1.07)		
Constant	.0069 (1.72)			.005 (2.47)		
Region specific education (a full set of region specific intercepts are also included, but not reported)						
High income oil-exports		-1.81 (.287)	2.86 (.429)		-.299 (.701)	-.64 (1.25)
MENA (excluding oil) exports		-.62 (2.21)	-.328 (1.10)		-.074 (.35)	-.34 (1.29)
Sub-Saharan Africa		-.07 (.87)	.033 (.393)		-.033 (.428)	.105 (.77)
South and East Asia		.42 (1.04)	.158 (.367)		-.066 (.427)	-.28 (.556)
Latin American & Caribbean		.286 (.953)	-.116 (.369)		.030 (.115)	.125 (.429)
High Performing East Asia		-.046 (.110)	-.196 (.44)		-.124 (.324)	.056 (.115)
OECD		.171 (.954)	.216 (1.14)		.222 (.485)	.253 (.739)
N	79	79	79	91	91	77
Adjusted R-Square	.540	.581	.613	.645	.662	.556

Note: Data is not always available so the same set of countries are not in every regression.

MENA: Algeria, Egypt, Jordan, Malta, Morocco, Syria, Tunisia, Turkey, Yemen.

High Income Oil Exporting Countries: Bahrain, Iran, Iraq, Oman, Saudi Arabia, United Arab Emirates.

High Performing East Asian: Hong Kong Korea, Malaysia, Singapore, Thailand, Taiwan

III. Quality of Schooling

One possible reason the expansion in education has not had the expected growth effect at the macro level is that schools might be of very poor quality. While it is certainly true that greater attention needs to be given to school quality, there are two arguments against this being the reason for education's smaller than expected contribution to output growth.

First, there is some direct micro evidence from MENA countries about the magnitude of learning. Unlike some countries where the answers on tests of school children appear no better than random (see Glewwe, 1996, for evidence on Ghana) children do appear to have learned something. There is evidence both from Morocco (Lavy, Khandker, and Filmer, 1995) and Egypt (Hanushek and Lavy, 1995 and Fergany, 1994) about the magnitude of achievement gains per year of schooling. These gains, while not overwhelming, are significant and positive. Second, there are differences across individuals in non-market outcomes by level of education that would be difficult to explain if schooling were so poor that little or nothing was learned. For instance, Table 7 shows the ratio of infant mortality and desired fertility of women with a secondary education versus women with no schooling. Clearly more educated women have substantially better (maternal) mortality outcomes and fewer desired children which would be difficult to explain if nothing at all were learned in school. Glewwe (1995) has shown using LSMS[3] data with direct observations on maternal knowledge of basic health facts that most of the schooling effect on infant mortality is accounted for by better knowledge.

Table 7: Differentials in Infant Mortality and Desired Fertility, Ratio of Secondary Educated to Uneducated Women

Country	Year	Infant mortality	Desired fertility
Morocco	1992	25%	64%
Tunisia	1988	46%	74%
Egypt	1992	31%	81%
Yemen	1992	46%	68%
Jordan	1990	57%	79%

Source: Demographic and Health Surveys, various years.

A third possible argument against the explanation of low growth impact of education on the basis of low quality is that there is an observed wage increment at the individual level, individuals with more schooling do make more money. If quality was so low that individuals learned little or nothing from school, then why would the market be rewarding schooling with higher wages? However, this argument is particularly problematic in the MENA case, as the next section will discuss.

[3] Living Standard Measurement Survey—a detailed survey of household and individual characteristics and expenditure and income.

IV. Micro Estimates of Returns to Schooling

Returns to schooling may actually be lower than reported due to the following reasons. First, micro estimates of returns to schooling exclude agriculture, where the returns to education are likely to be lowest.[4] In fact, in technologically-stagnant agricultural settings the return is likely to be close to zero as has been found in several studies (Jamison and Lau, 1982; Foster and Rosenzweig, 1996; Schultz, 1964; Joliffe, 1996; Gurgand, 1996).

Second, this use of formal sector wage employment excludes the informal sector. Again, in the informal sector the returns to schooling may well be low, either because it is not technologically dynamic in its skill requirements or because the content of the schooling typically received is irrelevant to the informal sector.

Third, particularly in the MENA countries, many formal sector workers, such as those with education beyond primary school, are in the public sector. If the government pay scale rewards "degrees" then labor force surveys or samples that include a large number of government workers will simply recover estimates of the government pay scale. This government pay scale may or may not be correlated to actual productivity.

To determine the impact of examining only formal sector workers, consider the overall expected gains to a given individual from additional education which can be decomposed into a change in occupation effect and an earnings within an occupation effect. If we divide occupations very crudely into formal (f) and non-formal (nf) (including urban and rural non-farm with informal and farm self-employment) then the decomposition of earnings with level of schooling, $s' > s$ can be written:

$$P_f(s)*[E_f(s') - E_f(s)] + P_{nf}(s)*[E_{nf}(s) - E_{nf}(s')] + [P_{nf}(s) - P_{nf}(s')] * [E_f(s')] - [E_f(s')]$$

where P is the probability of working in the sector with level of schooling s, and E is the earnings in a given sector with a given level of education. This equation illustrates the three factors in the overall expected economic return to an individual: the return in the formal sector, the return in the informal sector, and the change in probability of finding a job in the formal versus informal sector.

If the wage gains from schooling are estimated only from the earnings of workers where the return to education is the highest then obviously the true average return will be significantly overstated. Certainly during the boom periods, when public sector resources were plentiful, the situation may well have been that wages in the formal sector (and particularly the government) were relatively high. Also, the probability of obtaining a job in the formal sector may have depended critically on acquiring a good (and perhaps university) education. But the probability of getting the formal sector job *on average* for all entrants with primary schooling was low.

So, one explanation for the high observed microeconomic return to education with little growth impact is that the labor market has a dualistic structure with a formal sector in which education leads to higher wages (whether or not it contributes to productivity) and jobs are

[4] This is difficult to document as measuring "incomes" in traditional agricultural settings is problematic, which makes estimating the income or productivity gain to education similarly difficult.

rationed by tests or educational degrees.[5] In this case the observed return to education of those who actually receive work in the formal sector may be high, and the demand for schooling may also be high, and yet the actual growth impact of education very low.

V. Government Employment and Private and Social Returns to Education

This last point about sectoral shifts raises another critical issue: the influence of government activity as an employer on the private returns to schooling and the actual social returns. It may well be that government interventions in the labor market as an employer of last resort result in a situation in which there is a large private return to securing a government job but that each additional government employee lowers growth (Gelb, Knight and Sabot, 1988). The government does not act as a profit maximizing firm. So, for instance, the government may not have paid their workers according to their opportunity cost or productivity in the private sector. In this case the government can (and most probably did) distort the market for educated labor. Whereas if most employers were paying wages that generated long queues for their jobs, they would be tempted to reduce wages. Many governments respond to political pressure by striving to expand employment to meet the "need" for jobs that they themselves have generated by paying excess wages. This leads to a situation in which governments are taking resources away from non-governmental activity in the form of taxes in order to pay additional workers whose marginal product in the public sector is very low.[6]

This situation is particularly easy to maintain if the government has access to a large amount of resources without resorting to taxation—for instance, oil revenues. But when the government suddenly runs short of resources several things typically occur. First, employment expansion slows. Second, average wages fall. Third, the wage premia in the civil service are compressed (principally because there is only so far the bottom of the wage scale can fall in absolute terms). These factors completely change the dynamics in the labor market and in particular the returns to education. If the entire educational system has been geared towards preparing students to pass the appropriate exams to enter into government employment then the system faces a large crisis.

It is worth noting that the crisis may not be immediately visible from observing wages, since wage surveys measure the *average* return to education, that is for workers over all ages while what is relevant for the labor market entrant is the *marginal* return for his/her cohort of workers.

Also, all of this assumes that additional government workers were at worst unproductive. It is certainly possible that the combination of over employment with very low wages may produce a situation in which government workers granted powers of various kinds are induced to generate rents for themselves, reducing economy-wide productivity.

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[5] "Dualistic" means that for some reason the two parts of the labor market are not fully integrated so that one can maintain a wage premium in the formal sector.

[6] Their marginal product is low not necessarily because of malfeasance but because there is over-staffing relative to the optimal employment levels. In addition, the wage bill crowds out other expenditures (*e.g.*, recurrent expenditures) for complementary inputs.

VI. Three Additional Points

A) Returns to Education in Farming

Since many of the MENA countries (particularly Egypt) still have a relatively large agricultural work force, it is worth estimating the return to education in agriculture. It is probable that in technologically-stagnant environments the returns to education are very low, while, if the agricultural sector is technologically dynamic, they may well be reasonably high. The evidence most directly relevant is a recent paper by Rosenzweig and Foster (1995) which examines the pattern of returns to education across various regions of India.[7] The authors find that there are substantial differences in the returns to education across various districts and that these differences depend heavily on the degree to which the districts were amenable to adoption of Green Revolution technologies, which produced exogenous differences in the growth of potential productivity. In those districts with high exogenous productivity growth, the return to primary schooling vs. no schooling (measured as incremental net farm profits) was reasonably high, around 8 percent per year of schooling. However, the average return across all districts is very low, only about 2.3 percent. Moreover, in those districts in which technical progress was low, the return to education was similarly low. In fact, for the majority of the districts the returns to education were indistinguishable from *zero*.[8]

B) Trade Reform and Returns to Education

The conventional wisdom from the trade models which predict trade composition based on factor intensity based comparative advantage (such as Hecksher-Ohlin) is that trade liberalization would reduce wage premia, that is, lower the return to education in developing countries.[9] There are three reasons why this may not be the case.

First, much of the return to education consists of the higher order skills of adapting to new information. In an open economy where firms are forced to compete, both the quantity of information available and the pressures to adopt it will increase. Therefore, the return to education may well increase.

Second, for the middle tier developing countries it is not clear that they possess a comparative advantage in unskilled labor intensive exports. Though compared to Europe, MENA possesses substantial low cost unskilled labor, it is not competitive with other countries which sell to the European market such as China and Indonesia. The MENA countries do not want to compete with those countries on labor costs by lowering wages, which implies that either their productivities will have to be much higher or that the range of goods they export may well not be particularly unskilled labor intensive even after complete liberalization.

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[7] Similar information is not available for MENA at present.

[8] The estimates below zero are likely an artifact of the linear interactive functional form.

[9] The intuition is very clear. Since opening up trade with a developed country is like expanding the availability of factors, this clearly increases the supply of educated labor available to the domestic economy which should therefore decrease the relative price of skilled labor.

Third, much of the return to education is captured by the skill of adapting to disequilibria. This implies that in any transition (irrespective of length), such as from a closed to an open economy, we would expect to see, at least during the period of transition, the return to education increasing.

C) Technological Skill Bias in the World Production Frontier

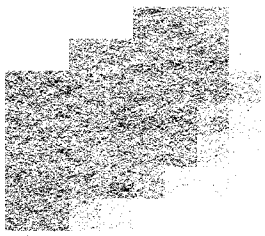
As a final point, the returns to schooling have increased significantly in the United States, which is a skill-intensive economy. Yet, the returns to skill acquisition are increasing even as the supply of skills expands, because the demand for skilled labor is outpacing supply. If the demand for skilled labor is increasing then this is likely because recent technological progress has been skill-biased, in that it has raised the productivity of skilled labor more than unskilled. This may have an unfavorable message for countries such as those in MENA, where the average level of schooling of the labor force is far less than an "uneducated" worker in the United States and Europe, and for whom demand is falling.

Conclusion

Education clearly has enormous pay-offs at the individual level in providing benefits to the household directly and indirectly through better job prospects.

However, it is clear that education has not been as productive as it could have been in the MENA context. The rapid expansion in education appears not to have paid off in terms of improved economic growth. The evidence points to two conclusions:

- the distorted economies and labor markets (particularly government hiring practices) in the pre-reform period led educated labor to be less productive than was its potential.
- in the post-reform period education will take on greater importance, in particular, policy-makers should focus on increasing the quality of education so that the future labor force will have the skills to be productive in more technologically-complex economies of the future.



Appendix 1: Calculation of Observed Factor Accumulation, TFP, and Implied

The calculations of TFP reported are based on a number of simplifying assumptions about the nature of the aggregate production function which are described in this appendix.

Equations. The formulas are simple, one begins with a Cobb-Douglas production function in labor, physical capital and human capital with a scale factor that implies neutral technical progress.

$$Y_t = A(t) * K_t^{\alpha k} * H_t^{\alpha h} * L_t^{\alpha l}$$

Impose constant returns to scale, so that

$$\alpha_k + \alpha_h + \alpha_l = 1$$

Normalize to the growth of output per worker, take logs and differentiate with respect to time and the following equation is a definition of TFP:

$$\dot{y} = \alpha_k * \dot{k} + \alpha_l * \dot{h} + TFP$$

where lower case with dots is the percentage rate of change of per worker quantities. All of the calculations are done with the per annum rate of change estimated with a least squares trend over the entire period of data availability (generally 1960 to the late 1980s).

Data. To empirically implement the above equation one needs data on the four items that enter the equation, GDP, physical capital stock, human capital stock, and labor force. For each of those quantities I have two data sources, which are described in the table below. All of the results in the paper, unless otherwise specified are based on the set of data in the first column (Summers-Heston, King-Levine, Barro-Lee) but all calculations were also performed using the set in the second column (World Bank, Nehru-Dhareshwar, Nehru-Swanson-Dubey), with roughly similar results overall. The correlation between the two TFP growth rate series is 0.77.

Appendix Table A1.1: Description of Data Sources for TFP Calculations

Variable	Data collection I: Summers-Heston, King-Levine, Barro-Lee	Data collection II: World Bank, Nehru-Dhareshewar, Nehru-Swanson-Dubey
GDP	Source: Summers and Heston, 1991. Penn World Tables, Mark 5	Source: World Bank data
	Description: Real GDP (RGDPCH) expressed in purchasing power equivalents.	Description: Real GDP in local currency, constant prices.
Labor Force	Penn World Tables, Mark 5	Penn World Tables, Mark 5
Physical Capital Stocks	Source: King and Levine (1994)	Source: Nehru and Dhareshewar (1993)
	Capital stock series in P$ based on a perpetual inventory cumulation of the investment rates in the PWT5 from an estimate of the initial capital stock in 1960.	Capital stock series in constant US$ based on a perpetual inventory cumulation of investment rates in the World Bank National Accounts data.
Human Capital	Source: Barro and Lee, 1993 and Pritchett, 1996.	Source: Nehru, Swanson, and Dubey, 1993 and Pritchett, 1996.
	Description: The underlying data on years of schooling of adult population (>25 years) are computed by Barro and Lee based in Census reports of educational attainment and enrollment rates. Pritchett (1996) calculates the human capital stock based on the years of schooling from assumed returns to schooling.	Description: The underlying data on years of schooling of the labor force aged population (>15 years) are computed by N-S-D based on a perpetual inventory cumulation of historical enrollment rates (adjusted for repetition, drop out). Pritchett (1996) calculates the human capital stock based on the years of schooling from assumed returns to schooling.

Parameters. The final items needed for the TFP calculations are the shares of physical and human capital. For the calculations in this paper the author assumes that the capital share α_k is 0.4, the labor share is 0.6 and that half the labor return is human capital, so the human capital share α_h is 0.3. These particular values can be justified on a variety of bases, but any reasonable set of parameters will produce quite similar results, particularly in terms of patterns across countries.

Appendix Table A1.2: Regressions of TFP on Various Factors

		Using Summers-Heston, Barro-Lee, King-Levine	Using World Bank, Nehru-Dhareshwar, Nehru-Swanson-Dubey
Constant		10.8 (2.73)	10.37 (2.29)
OECD dummy		-.055 (.082)	-.347 (.381)
Initial Years of Schooling		.58 (2.60)	.561 (2.41)
Initial Income		-1.95 (2.82)	-1.58 (2.52)
Sachs-Warner Dummy for Closed Economies		-10.18 (2.49)	-9.63 (2.28)
Interaction of initial income and Sachs-Warner		1.24 (2.44)	1.18 (2.24)
Interpretation of interactive effects with openness and initial income			
Impact of lower initial income	Open	1.95	1.58
	Closed	.71	.40
Impact of being more open	One std. dev. below mean	1.58	1.45
	Mean income	.56	.47
N		89	79
R-Square		.283	.391

Notes: Instrumental variables regressions account for measurement error in the education stocks. Absolute values of t-statistics in parenthesis.

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